Chapter 3

SOILS IDENTIFICATION AND CLASSIFICATION

Note: The material covered in this chapter is for information only and will not be covered in this course.

Earth Materials

Common Excavation

Common Excavation is that soil material, shale and certain soft rock, which is encountered within the project limits as set out in the plans, and is noted for removal. This should not be confused with other types of excavation, such as waterway, unclassified, etc.. Common excavation may or may not be used for embankment construction, however, borrow is not used until all suitable common excavation has been used.

Borrow

Borrow is soil material, never shale, for the construction of embankment which is obtained from locations or sources outside of the right-of-way.

In either case, borrow or common excavation, should never contain trash, organic matter (including roots sod and stumps), or materials which are toxic to humans or the environment.

Comments

In order to identify these materials one must know something about their origin and have a systematic method of identification. The following information is intended to provide the user with those tools.

A knowledge of what the earth is made of is very important in highway work. Most of the material used in building roads is taken from suitable deposits of materials developed in the earth's crust by natural processes. Highways are supported by natural soil and rock materials which lie beneath them. Rock, soils, and aggregates are the material types.

Earth materials, as found in nature, are either soil or rock. Originally, all of this material was in the form of rock, occurring in large solid masses or deposits, each of which covered large areas of the earth's surface. Through the action of wind, water, temperature changes, plant activity and similar natural agents, the surface of these rock masses became decomposed, broken up, worn and washed away, and mixed with water and organic material.

In general, soil is any collection of this finer material that resulted from the breaking-up of the original solid rock, provided that it has still remained in the finely-divided form, and is easily divided into grains.

Actually, the distinction between soil and rock is quite technical because the fine material has often been cemented or welded back into a new rock. In highway work, a deposit is called soil instead of rock if a sample taken from it cannot go through a process of being thoroughly dried out and wetted again without crumbling.

Through the centuries, geological processes have accumulated deposits of soil which are very large, both in area and depth. Soil and rock, are the principal materials used in highway work. When a material having special characteristics (such as the size and type of each particle) is taken from a soil or rock deposit by screening or crushing or otherwise manufactured, it is called an aggregate. This section is concerned with these three materials: rock, soil, and aggregate.

Rock Principal Types

The principal types of rock found in Indiana is sedimentary (shale, limestone and sandstone). Bedrock is near the surface and is very significant to highway construction in only the southern 1/5 of the State. In the northern 4/5 of the state, rock is usually deeper than ordinary highway excavation. Over a major portion of the north, soil is over 90 to 120 meters (300' to 400') deep. The types of rock include:

* Igneous rocks originated from molten magma. They are the parent rocks of all others. Some kinds are granite, basalt, trap rock, gabbro, diabase, and rhyolite.
* Sedimentary rocks are derived from the fragmentation, disintegration and reconsolidation of other rock material. Some kinds are limestone, sandstone, shale, conglomerate and chert.
* Metamorphic rocks are derived from igneous and sedimentary rocks which have been changed texturally and mineralogically by pressure and heat. Some kinds are schist, slate, marble, gneiss and quartzite.

The slope of the bedrock is known as the dip. In Indiana the bedrock dip is essentially flat. Flat grades may follow the same rock types for some distance in excavations.

Residual soils are soils formed in place by mechanical and chemical decompositions. The shales, limestones and sandstone produced most of the soil in the southern 1/5 of the State.

Glacial soils and landforms are also known as transported soils and are found over the northern 4/5 of Indiana. As the great ice sheets moved down from the North, they transported soil and rock. As the ice melted, it dropped this material into various distinct landforms or shapes. Meltwater from the glaciers also helped shape northern Indiana by its carving action and deposition of materials. The wind produced other landforms and deposits.

Ground moraines are "plain-like" landforms and "ridge moraines" are rolling hills in Indiana. The soil and rock materials were deposited directly from the ice. Material in the northern 1/5 of the State is predominantly granular. The middle 3/5 is predominantly a silty clay.

Landforms and deposits produced by glacial meltwaters are.

* River Terraces
* Outwash Plains
* Lake Beds
* Beaches

Wind-Blown Soils and Landforms are.

* Sand Dunes
* Loess Plains

Soil Horizons

Soil horizons (layers) eventually form in the upper portions of soils by the action of water leaching downward through the soil. Color and soil texture differences allow you to tell the horizons apart.

A-Horizon

The A-horizon is the top layer and is often called topsoil by the layman. The A-horizon may contain a lot of organic material. Percolating water transports a portion of the clay from this layer into the lower layer. In Indiana, The A-horizon may measure from several inches to several feet in thickness.

B-Horizon

The clay materials leached from the A-horizon collect in the B-horizon. The B-horizon is also usually darker in color and more impermeable than the A-horizon. The B-horizon may also range from several inches to several feet in thickness.

C-Horizon

The C-horizon is the original soil (or parent material) which has not been materially altered.

Soil horizons are usually relatively thick and strongly developed in soils lying in low areas such as alleys, basins and even in small depressions. These areas collect more surface water so that there is more leaching from the A-to B-horizons which makes both the A and B horizons thicker than in higher easier draining locations.

Soil Components

The soil components are gravel, sand, silt, clay and organic materials. A soil may be composed entirely of a single component or may be a mixture of two or more components in any percentages.

Coarse grained components are gravel and sand. These can easily be identified in the field by their grain size. Gravel is composed of particles ranging in size between 3" (76 mm) to a #10 (2 mm) sieve. Gravel will pass a sieve with 3" (76 mm) square openings and be retained on a #10 (2 mm) sieve.

Sand ranges in size between a #10 (2 mm) sieve and #200 (0.075 mm -- about the smallest size recognizable with the unaided eye). Coarse sand particles pass the #10 (2 mm) sieve and are retained on the #40 (0.42 mm). Fine sand will pass the #40 0.42mm) and can be retained on the #200 (0.075 mm) sieve.

Fine grained components are silt and clay. Both will pass the #200 (0.075 mm) sieve. Silt and clay particles are too small to be distinguished by eye in the field. They are distinguished mainly by plasticity. Clay is plastic or putty-like, while silt is relatively non-plastic.

Organic components are largely decayed plant matter. They may be found in any degree of decomposition. Peat is decayed plant material in which fibrous wood-like fragments can be recognized. Marl or Muck are thoroughly decomposed organic material generally containing a considerable amount of silt, clay and possibly some fibrous remains.

Soil Textures

The term soil texture describes, in general terms, the size and distribution of the components in a soil. The soil textures that the inspector should be able to identify in the field are: sand, sandy loam,, silt loam, silt, clay loam, clay and organic soils. Loam refers to a mixture of clay, silt and sand. (See Table 1).

Field Identification Tests

Clay and silty soils can be identified and distinguished in the field by one or more of the following simple tests:

* The plasticity test can be performed in the field by rolling a fine grained soil into a thread of about an 1/8" in diameter. The test applies only to soil that is damp (moisture content about the same as that of a soil which exists 1 or 2 feet below the surface but above the water table. Fine-grained soils which are predominantly clay, can be rolled into relatively long, firm threads. Predominantly silty soils can be rolled into a thread but the thread is very easily broken.

TEXTURE CLASSIFICATION OF SOILS

Soil Texture	Visual detection of Particle Size and general appearance of the soil	Squeezed in hand and pressure released		Soil ribboned between thumb and finger when moist.
		When Air Dry	When Moist	
Sand	Soil has a granular appearance in which the individual grain sizes can be detected. It is free-flowing when in a dry condition.	Will not form a cast and will fall apart when pressure is released.	Forms a cast which will crumble when lightly touched.	Can not be ribboned.
Sandy Loam	Essentially a granular soil with sufficient silt and clay to make it somewhat coherent. Sand characteristics predominate.	Forms a cast which readily falls apart when lightly touched.	Forms a cast which will bear careful handling without breaking.	Can not be ribboned.
Loam	A uniform mixture of sand, silt and clay. Grading of sand fraction quite uniform from coarse to fine. It is mellow, has somewhat gritty feel, yet is fairly smooth and slightly plastic.	Forms a cast which will bear careful handling without breaking.	Forms a cast which can be handled freely without breaking.	Can not be ribboned.
Silt Loam	Contains a moderate amount of the finer grades of sand and only a small amount of clay over half of the particles are silt. When dry it may appear quite cloddy which readily can be broken and pulverized to a powder.	Forms a cast which can be freely handled. Pulverized it has a soft flourlike feel.	Forms a cast which can be freely handled. When wet, soil runs together and puddles.	It will not ribbon but it has a broken appearance, feels smooth and may be slightly plastic.
Silt	Contains over 80% of silt particles with very little fine sand and clay. When dry, it may be cloddy, readily pulverizes to powder with a soft flourlike feel.	Forms a cast which can be handled without breaking.	Forms a cast which can freely be handled. When wet, it readily puddles.	It has a tendency to ribbon with a broken appearance, feels smooth.
Clay Loam	Fine textured soil breaks into hard lumps when dry. Contains more clay than silt loam. Resembles clay in a dry condition; identification is made on physical behavior of moist soil.	Forms a cast which can be freely handled without breaking.	Forms a cast which can be handled freely without breaking. It can be worked into a dense mass.	Forms a thin ribbon which readily breaks, barely sustaining its own weight.
Clay	Fine textured soil breaks into very hard lumps when dry. Difficult to pulverize into a soft flourlike powder when dry. Identification based on cohesive properties of the moist soil.	Forms a cast which can be freely handled without breaking.	Forms a cast which can be handled, freely without breaking.	Forms long, thin flexible ribbon. Can be worked into a dense, compact mass. Considerable plasticity.
Organic Soils	Identification based on the high organic content. Muck consists of thoroughly decomposed organic material with considerable amount of mineral soil finely divided with some fibrous remains. When considerable fibrous material is present, it may be classified as peat. The plant remains or sometimes the woody structure can easily be recognized. Soil color ranges from brown to black. They occur in lowlands, in swamps or swales. They have high shrinkage upon drying.			

TABLE 1.—*Field Method for identification of soil texture.*

* The dry strength test is performed often on fine-grained soils by beating or crushing a piece of dried soil with the hands or fingers. A piece of dry clay is extremely difficult to break. A dry silt can be crushed relatively easily with the fingers.
* The "pat" or "shake" test is performed on fine grained soils as follows. Add enough water, if necessary, to make a soil pat (about 16 cc [1/2 cubic inch] in size) soft but not sticky. Place the pat in the palm of the hand and shake the hand horizontally, jarring it against the other hand. This action will bring moisture to the surface and make the soil appear shiny if it is mainly a silt. A slight squeeze of the pat should make the moisture withdraw. The surface should crack and have a dull appearance. A clay soil will not permit the water to come to the surface when shaken.
* The settlement rate in water test can be performed by placing about 10 cc (2 teaspoons) full of fine-grained soil in a clear container, filled with water and shaking the container well. If the sample is primarily silt, the particles will settle to the bottom of the container in about 30 seconds and leave the water nearly clear. Clays will remain in suspension for a much longer time and leave the water dark and cloudy in appearance.

Sands And Gravels

These soil components can be distinguished quite accurately just by looking at the size of the particle. There are two simple field tests that may be used to determine if granular materials are "clean" or "dirty."

* The dust formation test is performed when the granular material is dry by sifting the granular material through the fingers and letting it fall on a clean hard surface. If a large amount of silt and clay are present, it will be noted as dust as the material strikes the hard surface.
* The settlement rate in water test, as described in the tests for fine-grained soils, can also be used to determine the cleanliness of sands. For "clean" sands, the water should clear in 30 seconds. If the sand is "dirty" the water will remain cloudy for longer than 30 seconds.

Marl, Muck And Peat

These can be identified by visual inspection, color, smell, density and compressibility. Visual inspection may show decomposed plant and /or animal remains and shells. The color of organic soil is usually black or dark grey. The odor may be slight to strong. The density of muck, marl, or peat is considerably less than that of inorganic soils.

Summary

It is important for you to know what the earth is made of because most of the materials used to build roads is taken from the earth. These materials include rocks, soils, and aggregates.

The type of rock found in Indiana is sedimentary (shale, limestone, and sandstone). The following rocks are found in the State:

* Igneous Rock.
* Sedimentary Rock (glacial till deposit).
* Metamorphic Rock (glacial till deposit).

Indiana's soils were formed by mechanical and chemical decompositions, glaciers, and wind. Soil is made up of three layers called horizons. Color and soil texture allow you to tell the horizons apart.

Soil is composed of:

* coarse-grained components (gravel and sand)
* fine-grained components (silt and clay)
* organic components (peat, marl, and muck)

The texture of a soil refers to the size and distribution of the soil's components.

Clay and silty soils can be identified in the field by simple tests. Sands and gravels can be identified by looking at the size of the particle. Muck and peat can be identified by visual inspection, color, smell, density, and compressibility.

Method Of Field Classification For Indiana Soils

In general, the soil classification for each soil type must include a description of:

* Color
* Moisture
* Consistency or density
* Textural classification

Modifiers

And if applicable, should include items:

* Modifying terms for amounts of materials such as; rock fragments, gravel, shale, etc. which are not included in the textural classification, e.g. "trace", "little", "some", or "and" have definite meanings as to percent content in the sample.
* Modifying terms for amount of organic in soils use the same terms, "trace", and "little" but have different meaning as to percent content by weight.

* Use of common general terms, (fill, peat, marl), etc. can be very helpful and should be shown in parenthesis immediately following the usual soil classification.

Specifically, the following suggestions should be followed regarding the above:

* Use color combinations such as greenish-gray, yellowish-brown, etc. and different hues such as light brown or dark brown. Study the soil carefully in a wet condition to determine color.
* Moisture description should range from wet, very moist, slightly moist, to dry.
* Consistency descriptions used for cohesive or plastic soils include:

  * very soft
  * soft
  * medium stiff
  * stiff
  * very stiff
  * hard

* Relative density descriptions used for non-cohesive, non-plastic soils include:

  * very loose
  * loose
  * medium dense
  * dense
  * very dense

* Textural classification should be determined from the relative proportions of sand, silt, and clay from the attached chart.
* Modifying terms for amounts of materials other than organic, which are included in the textural classification as discussed above, should be used as follows:

  * With trace of ____________ = 0% to 10%
  * With little ____________ = 11% to 20%
  * With some ____________ = 21% to 35%
  * "and" ____________ = 26% to 50%

* Modifying terms for describing amounts of organic and marl contents in a soil, have different ranges of percent content meanings.

* The use of common general terms in conjunction with the usual soil classification can be very helpful in interpretation of the origin of material in the soil profile. The field inspector should note in parenthesis after

the usual classification such terms as:

* fill material
* apparently natural ground
* peat
* muck
* marl
* till
* old lake bed
* etc.

Classification Of Soils

Some common definitions include:

* Boulders	Retained on 3" (76 mm) sieve
* Gravel	3" (76 mm) to #10 (2 mm) sieve
* Coarse sand	#10 (2 mm) to #40 (0.42 mm) sieve
* Fine sand	#40 (0.42 mm) to #200 (0.075 mm) sieve
* Silt	0.075 mm to 0.002 mm
* Clay	smaller than 0.002 mm
* Colloids	smaller than 0.001 mm

Classification

Classification	%Sand & Gravel	%Silt	%Clay
Sand	80-100	0-20	0-20
Sandy Loam	50-80	0-50	0-20
Loam	30-50	30-50	0-20
Silty Loam	0-50	50-80	0-20
Silt	0-20	80-100	0-20
Sandy Clay Loam	50-80	0-30	20-30
Clay Loam	20-50	20-50	20-30
Silty Clay Loam	0-30	50-80	20-30
Sandy Clay	50-70	0-20	30-50
Silty Clay	0-20	50-70	30-50
Clay	0-50	0-50	30-100

Classification

Classification	% Sand & Gravel	%Silt	%Clay
Sand	80-100	0-20	0-20
Sandy Loam	50-80	0-50	0-20
Loam	30-50	30-50	0-20
Silty Loam	0-50	50-80	0-20
Silt	0-20	80-100	0-20
Sandy Clay Loam	50-80	0-30	20-30
Clay Loam	20-50	20-50	20-30
Silty Clay Loam	0-30	50-80	20-30
Sandy Clay	50-70	0-20	30-50
Silty Clay	0-20	50-70	30-50
Clay	0-50	0-50	30-100